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ABSTRACT

The Urban Mathematics Collaborative (UMC) project has the goal of contributing to the improvement of mathematics education in the inner-city schools by identifying models to enhance the professional lives of teachers and encouraging the entry of high school mathematics teachers into a larger mathematics community including mathematicians from higher education and industry. This document is a 5-year site report on the Pittsburgh Mathematics Collaborative from its inception in 1985 through June 1990. The intent is to reflect on the development of the collaborative, noting the changes that have taken place in regard to the context in the collaborative operated, the collaborative's management structure, and the focus of its activities. This final site report addresses the major influences exerted on the collaborative and the directions the collaborative has taken. Some conclusions are reached regarding both the collaborative's development and achievements in light of its specific goals as well as the goals of the total UMC project. (MDH)

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PITTSBURGH MATHEMATICS COLLABORATIVE

FIVE-YEAR SITE REPORT

A Final Report to the Ford Foundation on the Urban Mathematics Collaborative (UMC) Project

Norman L. Webb, Susan D. Pittelman, Thomas A. Romberg, Allan J. Pitman, Edel M. Reilly, and James A. Middleton

Wisconsin Center for Education Research
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Norman L. Webb, Susan D. Pittelman, Thomas A. Romberg,
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Report from the
Urban Mathematics Collaborative Documentation Project

Wisconsin Center for Education Research
School of Education
University of Wisconsin
Madison, Wisconsin

December 1991

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I. INTRODUCTION

This document is a five-year Site Report on the Pittsburgh Mathematics Collaborative, from its inception in 1985 through June, 1990. The intent is to reflect on the development of the collaborative, noting the changes that have taken place in regard to the context in which the collaborative operated, the collaborative's management structure, and the focus of its activities. It is not the intent of this report to review the development of the collaborative through June, 1990; this has been done in the annual reports. This final Site Report addresses the major influences exerted on the collaborative and the directions the collaborative has taken. Some conclusions are reached regarding both the collaborative's development and achievements in light of its specific goals as well as the goals of the total Urban Mathematics Collaborative project.

The Urban Mathematics Collaborative Project

In 1984, the Ford Foundation initiated the Urban Mathematics Collaborative (UMC) project to improve mathematics education in inner city schools and to identify new models for meeting the on-going professional needs of teachers. In February, 1985, the Foundation awarded five grants to establish urban mathematics collaboratives in Cleveland, Minneapolis-St. Paul, Los Angeles, Philadelphia, and San Francisco. In addition, the Ford Foundation established a Documentation Project at the University of Wisconsin-Madison to chronicle the development of the new collaboratives and a Technical Assistance Project (TAP) at the Education Development Center (EDC) in Newton, Massachusetts, to serve as a source of information for the collaborative projects (Romberg & Pitman, 1985). During the next 18 months, UMC projects were funded in Durham, Pittsburgh, San Diego, St. Louis, Memphis, and New Orleans, for a total of eleven collaboratives (Webb, Pittelman, Romberg, Pitman, Fadell, & Middleton, 1989). In August, 1987, an Outreach Project was funded at EDC to publicize and expand the UMC effort. In August of 1989, the Ford Foundation awarded replication grants to three additional sites: Dayton, Ohio; Columbus, Georgia; and Milwaukee, Wisconsin. In April, 1991, the fifteenth and final collaborative, the Greater Worcester Urban Mathematics Collaborative, was established in Massachusetts. A map indicating the location of UMC projects is presented in Figure 1.

The
Urban Mathematics Collaborative Project

Funded by The Ford Foundation

- **Cleveland Collaborative for Mathematics Education (C^2ME)**
  Cleveland, Ohio
- **Durham Collaborative: The Durham Mathematics Council**
  Durham, North Carolina
- **Los Angeles Urban Mathematics/Science/Technology Collaborative (LAUM/S/TC)**
  Los Angeles, California
- **Memphis Urban Mathematics Collaborative**
  Memphis, Tennessee
- **New Orleans Mathematics Collaborative (NOMC)**
  New Orleans, Louisiana
- **Philadelphia Math Science Collaborative**
  Philadelphia, Pennsylvania
- **Pittsburgh Mathematics Collaborative**
  Pittsburg, Pennsylvania
- **St. Louis Urban Mathematics Collaborative**
  St. Louis, Missouri
- **San Diego Urban Mathematics Collaborative**
  San Diego, California
- **San Francisco Mathematics Collaborative**
  San Francisco, California
- **Twin Cities Urban Mathematics Collaborative**
  Minneapolis-St. Paul, Minnesota

Replication Sites

- **Columbus Regional Mathematics Collaborative (CRMC)**
  Columbus, Georgia
- **Dayton-Montgomery County Public Education Fund Mathematics Collaborative**
  Dayton, Ohio
- **Greater Worcester Urban Mathematics Collaborative**
  Worcester, Massachusetts
- **Milwaukee Metropolitan Mathematics Collaborative (M^3C)**
  Milwaukee, Wisconsin

Figure 1. The National Network of Urban Mathematics Collaboratives.

During the five years covered in this Site Report mathematics education in the United States has changed. When the Ford Foundation initiated the UMC project in 1984, a consolidated effort to reform mathematics had not yet begun, although the potential of the mathematics education community for achieving reform was envisioned. In this regard, the UMC project was innovative in mobilizing a group of inner-city teachers to increase both their sense of professionalism and their connections with mathematicians in the business community and in higher education. Between 1985 and 1990, mathematics education in this country changed dramatically. In an effort to develop a new mandate based on such studies as *Renewing United States Mathematics: Critical Resource for the Future* (Commission on Physical Sciences, Mathematics, and Resources, 1984) and *A Nation at Risk: The Imperative for Educational Reform* (National Commission on Excellence in Education, 1983), the Mathematical Sciences Education Board in 1989 issued *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* and the National Council of Teachers of Mathematics published *Curriculum and Evaluation Standards for School Mathematics*. As the collaboratives matured, the movement to change mathematics education in the country took on momentum, creating a new environment for the collaborative network. What began as a project designed to enhance the professional development of urban teachers evolved into a catalyst for the reform of mathematics education.

At each site, the UMC project supports collaboration among school mathematics teachers and between teachers and mathematicians from institutions of higher education and industry; it also encourages teacher membership and participation in a broad-based local mathematics community. Although the guiding principle behind the UMC effort is that the teacher is and will remain at the hub of the educational process, it has become evident that many teachers--and especially those in inner-city schools--are overworked; lack support and material resources; and are isolated from their colleagues, from other professionals, and from the rapidly changing field of mathematics. Thus, the focus of the UMC project remains rooted in the premise that collegiality among professional mathematicians can reduce teachers' sense of isolation, foster their professional enthusiasm, expose them to a vast array of new developments and trends in mathematics, and encourage innovation in classroom teaching.

Structure of the Five-Year Summary

The Five-Year Summary presented in the following chapter is comprised of six sections. The first section provides a brief overview of the collaborative. In the second section, the purpose of the collaborative is presented, as stated in its proposals to the Ford Foundation. The goals outlined in the collaborative's final request for funds to the Ford Foundation are contrasted with those specified in its initial proposal. The third section discusses the context within which the collaborative operated and how this has remained stable or has changed over the five-year period. Topics addressed in this section include demographic information on the surrounding community, changes in school district administration and enrollment and in the teacher population targeted by the collaborative, and significant changes occurring in mathematics and in the professional environment. The fourth section of the report describes the management structure adopted by the collaborative and how this changed over the five-year period. The fifth section covers the collaborative's activities in relation to four major themes that emerged from the documentation process as dominant in most collaboratives: socialization and networking, increased knowledge of mathematics content, teacher professionalism, and teacher leadership. These themes are used as a focus to organize ideas and to reflect on the collaborative's development with respect to some overriding expectations of the UMC project. The sixth and final section presents the reflections of Documentation Project staff on the approach the collaborative took to achieve its goals and the perceived outcomes in the areas of collaboration, professionalism, and mathematics focus.

The information presented in the Site Report is both a condensation and synthesis of information collected over the span of the UMC Documentation Project. Data were collected through monthly reports, the electronic network, four large-scale surveys, two demographic surveys, site visits, and case studies. These data-collection instruments and procedures are described in detail in the *UMC Guide to Documentation* (Pittelman, Webb, Fadell, Romberg, Pitman, & Sapienza, 1991). Detailed information about the Urban Mathematics Collaborative project is presented in six annual reports, four technical reports, and a set of case studies prepared by the Documentation Project. All of these reports are listed in the References. The Site Reports, which offer a retrospective summary of each collaborative's efforts over the grant period, have not been reviewed by

collaborative personnel and thus present the reflections solely of the Documentation Project staff.

II. FIVE-YEAR SUMMARY: 1985-1990

A. Overview

From its beginning, the Pittsburgh Mathematics Collaborative has consistently strived to increase the professional status of the high school mathematics teachers in Pittsburgh, primarily by embedding itself within the district's system of operations. In this sense, the evolution of the Pittsburgh Mathematics Collaborative has differed from that of other collaboratives by focusing on the modification of existing structures rather than on creating a new management framework. Certain conditions in Pittsburgh have made this a viable strategy. The size of the district is not overwhelming; the project coordinator, who has provided visionary leadership, has had very capable people to work with, including the district's director of mathematics and the collaborative liaison; the district administration was cooperative and innovative; and the district mathematics office has been competently staffed by five mathematics supervisors who work with the director of mathematics. While many of these conditions prevailed at other collaborative sites, nowhere did all of them exist simultaneously as they did in Pittsburgh.

Because of its interconnections with the district's mathematics program, the collaborative has reached all of the approximately 110 high school mathematics teachers in the district, each of whom has attended at least one inservice program co-sponsored by the collaborative. The collaborative has also been a major influence in advancing the use of technology in the district; it was instrumental in obtaining a set of calculators for each mathematics classroom and in nurturing the development of the computer committee. The collaborative helped cultivate leadership among mathematics teachers by institutionalizing the Instructional Teacher Leaders Groups, encouraging teachers to be more active in professional organizations, and providing workshops on leadership skills for teachers. It also supported the director of mathematics in her efforts to form groups of teachers to address issues of reform in the district's mathematics curriculum. Frequently, the work of the collaborative was indistinguishable from that of the district's Division of Mathematics because of the close and constant interaction between the collaborative's director and the district's director of mathematics. The collaborative operated with a minimum of governance--most decisions were made by the director in consultation with a small executive committee. Although representatives from the business and higher education sectors had some involvement, which was usually directed at specific tasks or events or in

conjunction with another program, very few participated in the collaborative over the long term. Leaders in the community were apprised of the collaborative's activities through the Board of the Allegheny Conference on Community Development. Among these activities were receptions, industry tours for teachers, inservices, and workshops. The teachers applied for and received a UMC Outreach Action Grant to conduct a conference on developing their interpersonal skills. In addition, the collaborative helped to support the work of curriculum and computer committees. After five years, an enlivened group of mathematics teachers was actively involved in addressing issues of reform of the mathematics curriculum. A new problem-solving course was instituted for ninth-graders and work was continuing on advanced algebra and trigonometry. A group of teachers, trained in using computers in the classroom, was helping others to become more comfortable with this technology; and many teachers became very active in communicating with other UMC teachers over the electronic network. Some teachers were initiating their own projects and studies on issues of importance to them and their schools. Thus, what the collaborative built was not so much a discrete organization as it was a new vision for teachers and others regarding their role as professionals as well as the mathematics they teach their students.

B. Purpose

Since its initial conceptualization, the purpose of the Pittsburgh Mathematics Collaborative (PMC) has been to increase the professional status of high school teachers of mathematics in Pittsburgh. The general strategy was to develop the self-concept of teachers and their knowledge of mathematics while working with the larger community to heighten its regard for teachers. Although refined and clarified in subsequent proposals, the general direction of the collaborative has remained the same as stated in its six goals:

1. To overcome teachers' isolation and to increase opportunities for interaction;
2. To educate the community about the professional nature of high school mathematics teachers;
3. To enhance teachers' knowledge base of mathematics applications;
4. To provide opportunities for professional self-enhancement;

5. To provide opportunities for teacher recognition; and
6. To provide time for teacher interaction, work, and professional development.

In addition to identifying the collaborative's goals, the original proposal also identified the objectives the collaborative sought to achieve by the end of its five-year Ford grant. The PMC was the only collaborative to look ahead to the end of the funding period and to envision the changes that should have occurred. In the proposal, the original goals of the collaborative, which described the processes to be followed, were reformulated to describe a vision of what should be: an energized secondary mathematics faculty; a more broadly-based community knowledgeable of mathematics issues and appreciative of teachers; the introduction of a series of mechanisms to promote exchange and interaction among teachers and community leaders; and a public made more aware of the importance of mathematics in students' educational development and in adults' professional lives. The steadfastness of the collaborative's vision and its goals are indicative of the strong influence exerted by the director. Whereas other collaboratives viewed the formulation of vision and goals as an opportunity for teachers to assume more responsibility for their own situation, in Pittsburgh setting the goals was primarily assumed by the administration, thus allowing teachers to become active and energized in other ways.

C. Context

The city of Pittsburgh, which covers a 55.5 square-mile area, has decreased in population over the span of the collaborative's development, from approximately 425,000 in 1985 to about 385,000 in 1990. The greater metropolitan area has a population of over 2.5 million. In a region where heavy industry traditionally dominated the economic balance, Pittsburgh is slowly developing as a cultural and high-technology oasis.

The decline in the city's population has been accompanied by a decrease in the enrollment of the Pittsburgh Public Schools (PPS) from 41,000 students in 1985 to 38,885 in 1989, a 5 percent decrease. In 1989-90, 11,657 students were enrolled in high school, 7,976 in middle school, and 19,252 in elementary school. The ethnic composition of the high school students has shifted over the five years of the collaborative from 52 percent black and 48 percent white and other ethnic groups in 1985, to 48 percent black and 52

percent white and others. Less than 1 percent of the students across all grades were classified as English-as-a-Second Language students in 1989-90. Thirty-six percent of the students were from families receiving AFDC; 50 percent (19,562) of the students participated in the government-funded lunch program. The percentage of children eligible to attend the district's schools who chose private or parochial schools remained at about 26 percent, a rate constant over the duration of the collaborative. The Pittsburgh schools had a cumulative dropout rate of 23 percent in 1989-90, which was calculated as a four-year comprehensive rate and projects the percentage of 9th-graders who are not expected to graduate.

The Board of the Pittsburgh Public Schools has nine elected members. During the 3-year period from 1987 to 1990, the budget rose by nearly 17 percent, from $269 million to over $313 million. Fifty-seven percent of the district's budget came from local funding, 34 percent from state funding, and 9 percent from other sources. Dr. Richard Wallace, Jr., served his tenth year as superintendent of schools in 1989-90. In 1989-90, there were 84 schools in the district: 11 senior high schools (Grades 9-12), 14 middle schools (Grades 6-8), 51 elementary schools (Grades K-5), and 8 other schools. This represented a decline of one high school and one middle school and an increase of two elementary schools since the beginning of the collaborative. This rather stable period was proceeded by a seven-year period during which 18 district schools were closed. A director of mathematics and five supervisors oversee the district's mathematics program.

During the 1989-90 school year, PPS employed 2,779 teachers of whom 985 taught in the high school, 720 in middle schools, and 1,074 in elementary schools. The high school teachers were comprised of 48 percent white males, 37 percent white females, 5 percent black males, and 10 percent black females. The number of high school mathematics teachers declined from 126 in 1985 to 104 in 1989-90. Eighty-six teachers taught mathematics in the middle schools in the 1989-90 school year. The ethnic distribution among the high school mathematics teachers varied somewhat from the ethnic distribution of the larger group of PPS teachers--58 percent white male, 32 percent white female, 2 percent black male, and 8 percent black female. All high school mathematics teachers in 1989-90 were fully certified and averaged 20 years experience in the classroom. PPS teachers are represented by the Pittsburgh Federation of Teachers (PRT), of which approximately 92 percent of the teachers are members. Teachers' salaries in 1989-90 for 189 days ranged from $23,500 for a beginning teacher with a bachelor's

degree to $47,800 for a teacher with a Ph.D. and 22 years of experience. The top salary on the scale had increased from $39,000 in 1986-87, or 22 percent over three years. A total of six full noninstructional days and three inservice half-days during the school year are included in the contract for Pittsburgh high school teachers.

The State of Pennsylvania requires that a student have three years of mathematics to graduate from high school. Although there is a mandatory district curriculum, schools differ considerably in their structure and course offerings as well as in academic achievement. As the collaborative was forming, a new problem-solving course was being developed that would feed students into algebra, replacing the former general mathematics course. Students not ready to take algebra after one year of the problem-solving course would take a second year of problem-solving before going into algebra.

A variety of professional enrichment programs were available to Pittsburgh teachers. Nearly every secondary school teacher participated in an eight-week session at the district-operated Teaching Center, located at Schenley High School, during which they worked with master teachers and learned about the Pittsburgh Research-based Instructional Supervisory Model (PRISM). This model is based on an adaptation of Madeline Hunter's Effective Teaching Model; procedures from the model were used to engage teachers in conversation about their teaching and to structure observations and evaluations. In 1987-88, to evaluate district personnel more effectively and to reduce the dropout rate, each high school was asked to develop a Center for Excellence. A committee of school administrators, teachers and others identified tasks to focus on and accomplish during the year. One high school, for example, developed a mentoring program while another focused on helping students make the transition from middle school to high school. During the same year, based on an agreement between the district and union, each class period was reduced by one minute. On Wednesday afternoons, using the 45 extra minutes from this reduction and 45 minutes from the teachers' own time, departmental meetings were held. This Teacher Interaction Period (TIP) was used at the discretion of the department heads to organize and plan as appropriate. The Allegheny Conference on Community Development made available to teachers mini-grants of up to $300 each to encourage creativity in the classroom and more effective methods of instruction. Mathematics teachers were also eligible to participate in events sponsored by the Mathematics Council of Western Pennsylvania, an active professional mathematics organization. One mathematics teacher attended an institute at Ohio State as part of the

Calculator and Computer Precalculus Project (C^2PC). Subsequently, Schenley High School was one of 86 high schools in the United States that fieldtested the C^2PC textbook.

D. Management Structure

The Pittsburgh Mathematics Collaborative was initiated in late 1984 when Barbara Scott Nelson of the Ford Foundation contacted Jane Burger of the Allegheny Conference Education Fund regarding the formation of a mathematics collaborative in Pittsburgh. By late March, 1985, a Steering Committee was formed, and in the summer of 1985 a proposal for funding was accepted. Instead of creating a new management hierarchy, the collaborative planners attempted to fit the project into the existing school district structure, a course of action unique among the UMC sites. In support of this vision, a highly centralized approach to managing the collaborative was adopted. Major decisions for the collaborative were made by the coordinator with some interaction with a select few who formed an executive committee that met monthly. Partly due to this approach, the management structure of the collaborative has not undergone any substantive changes during its existence.

The project coordinator, Dr. Leslie Salmon-Cox of the Learning Research and Development Center of the University of Pittsburgh, was instrumental in preparing the initial proposal and has remained at the helm of the collaborative over the five-year period. At the end of this period, as the collaborative's work was merging with that of the district, Dr. Salmon-Cox phased herself out of the collaborative's operation. Clearly, Dr. Salmon-Cox's leadership contributed to the stability of the Pittsburgh collaborative and its success in changing the culture of the district's mathematics program. Another contributing factor was the close working relationship among Dr. Salmon-Cox, the assistant collaborative coordinator (first Dr. Martina Jacobs, later Barbara Bridge), and the school district's director of mathematics, Dr. Diane Briars. The complementary skills and knowledge of these central planners were reflected in the distribution of collaborative tasks and responsibilities. The coordinator was primarily responsible for the political interaction with the district and the union, as well as for planning strategies and obtaining funds. The assistant coordinator, later called the collaborative liaison, was responsible for collaborative initiatives that involved business and industry and facilitated communications within the collaborative. Dr. Briars linked the collaborative to the district and was critical

in the effort to embed collaborative activities within district initiatives and needs. In addition, each of the three administrators interacted individually with collaborative teachers, and each actively worked with committees and assisted in planning.

Unlike other collaboratives, the Pittsburgh Mathematics Collaborative is inextricably linked to the local school district. At the start of the project, the district superintendent sent a letter to the chairs of the high school mathematics departments announcing the Pittsburgh Mathematics Collaborative as a "new resource program." One of the first tasks of the coordinator was to meet with the mathematics department chairs from each of the high schools to involve them in the process of organizing the collaborative, opening communication channels with teachers, and anchoring the collaborative to part of the existing structure within the district. The PMC coordinator and the director of mathematics worked together closely to ensure that collaborative activities were tied into the district's program--e.g., by helping to coordinate district inservices or forming a computer committee. All Pittsburgh high school mathematics teachers were considered members of the collaborative and were kept informed of collaborative involvement through the heads of their mathematics departments and the mandatory inservices.

Although the collaborative operated with committees, these committees assumed an advisory rather than a central role in collaborative decision-making. The Steering Committee was composed of nearly 30 members, including representatives from business and the universities, the school district, and several local funding organizations. It served as a sounding board to affirm the collaborative's development. In its latter years, the committee was chaired by Robert Wilburn, former Secretary of Education for the State of Pennsylvania and at the time of his Steering Committee tenure, director of the Carnegie Institute. This committee linked the collaborative with the larger community and kept it informed of the collaborative's activities. At its annual meetings, Steering Committee members were asked to react to the collaborative's program and plans. During the year, the coordinator called upon individual members for advice or political assistance. In 1989-90, the committee decided not to meet, an indication of the greater immersion of the collaborative into the district's program.

The Executive Committee, composed of Collaborative Coordinator Dr. Salmon-Cox, the assistant coordinator, Director of Mathematics Dr. Briars, Nancy Bunt of the

Allegheny Conference on Community Development, and Jeanne Berdik of the Partnerships in Education (PIE), served as the coordinator's confidants. Affectionately termed the "First Tuesday Group" because of its meeting time, this group provided timely review of the collaborative's program and was considered the collaborative's link with the school district. In addition to serving the needs of the coordinator, the other members valued their participation because of the opportunity for networking it offered. As the coordinator's collaborative involvement declined, so did that of the Executive Committee, and in 1989-90 the group met less regularly.

Both the Secondary and Middle School Instructional Teacher Leaders (ITL) Groups, comprised of the mathematics chairs of each of the high schools and of the middle schools, met monthly during the school year to devise district policy regarding all aspects of the secondary and middle school mathematics program. The collaborative was instrumental in initiating the secondary ITL Group and then in assisting with the formation of the middle school ITL Group. It also supported the work of both groups, which were important in providing communication between the collaborative administration and teachers and in making recommendations about what the collaborative should be doing. Both groups functioned as district committees. Meetings were conducted by the director of mathematics and members of her staff. On occasion, the two groups met jointly to discuss the articulation between middle and high school mathematics programs. The collaborative helped to arrange these joint meetings.

As part of the plan to decrease the coordinator's role in planning collaborative activities, in 1988-89 the Collaborative Liaison Committee was formed. This committee, comprised of one representative from each of the high schools, was charged with planning special gatherings of collaborative teachers. The assistant coordinator served as the convener of the group, which met regularly during the school year to orchestrate receptions for teachers and to develop ways to increase interaction among the mathematics teachers. In addition, the committee gathered information regarding the extent to which teachers take advantage of available resources such as grants, summer internships, and representatives from business as speakers.

The management structure for the collaborative was envisioned by the coordinator to be temporary. It was expected that the formal structure of the collaborative would eventually dissolve and that the district would change the organization of its mathematics

program to advance the goals of the collaborative--increased interaction among mathematics teachers, enhanced professional opportunities, and increased knowledge of mathematics among teachers. As the five years drew to a close, Dr. Salmon-Cox became less active in district mathematics program events. At the same time, the Instructional Team Leaders Groups met regularly to provide input into the mathematics program; the collaborative liaison, employed by the Allegheny Conference, provided a link to the Partnership in Education program; and the Liaison Committee attended to planning events to bring mathematics teachers together. Because essentially all of these activities were under the jurisdiction of the district, funding was not an issue. Some funding remained from the Ford Foundation grants to finance the operations of the Liaison Committee. Thus, the collaborative in Pittsburgh has become essentially invisible. In its place is a dynamic group of mathematics teachers working with the district's mathematics office to reform curriculum across the district, to research new approaches in using technology as well as other innovations, and to interact with colleagues throughout the district.

E. Project Activities

Over the five-year period, the Pittsburgh Mathematics Collaborative sponsored a variety of activities for the secondary mathematics teachers in the school district. During the 1988-89 school year, a grant from the National Science Foundation enabled the collaborative to extend its resources and services to middle school mathematics teachers. During the first year of the collaborative, teacher participation was mostly voluntary. Beginning in the 1986-87 school year, however, the collaborative planned annual district inservice programs that teachers were required to attend. In addition to the activities the collaborative sponsored, the PMC encouraged teachers to participate in professional development opportunities offered by other area organizations, including the rich array of programming offered by the Allegheny Conference on Community Development.

The activities of the Pittsburgh Mathematics Collaborative addressed the four themes that had emerged from the documentation process as being dominant in collaborative programming. These themes are: Socialization and Networking, Increased Knowledge of Mathematics Content, Teacher Professionalism, and Teacher Leadership. Socialization and Networking activities, especially prominent in the formative years of the collaboratives, were designed primarily to initiate interaction among teachers and between

teachers and mathematicians from business and higher education. These generally large-group activities were important to a collaborative's evolution since they brought members of the mathematics community together, enabled them to get to know one another, and promoted networking. The second theme, Increased Knowledge of Mathematics Content, encompassed activities designed to provide teachers with mathematics-directed experiences and to increase the knowledge of teachers and others regarding current trends in mathematics and mathematics education. Many of these activities helped to activate the agenda of the mathematics reform movement at the collaborative sites. The third theme, Teacher Professionalism, involved activities structured to enhance teachers' conceptions of teaching as a profession. Collaboratives provided opportunities and incentives for teachers to attend professional organization meetings and made mathematics teachers aware of available grants and other opportunities for professional development. Some collaboratives paid teachers' dues for organization membership and arranged for teachers to observe other teachers and reflect on their teaching. The fourth theme, Teacher Leadership, had not been identified at the beginning of the UMC project, but gained greater attention as collaboratives found that teachers lacked the skills needed to organize professional efforts, to plan, and to develop the power within their group to generate systemic change. This theme was advanced by the EDC through the UMC Teacher Leadership Workshops which, beginning in the summer of 1989, were attended by from one to four teachers from each of the collaboratives. However, since this training was initiated by EDC rather than by the collaboratives, it is not discussed in the reports of the individual collaboratives.

In reflecting on collaborative activities as they related to the four themes, considerable overlap was noted, since most activities served multiple purposes. A single activity may, therefore, be discussed under several headings.

Socialization and Networking

One of the Pittsburgh Mathematics Collaborative's six goals was to overcome teacher isolation and to increase opportunities for interaction among teachers. In working to achieve this goal, the collaborative offered a variety of programs to foster socialization, networking, and communication. These included receptions, kick-off parties, dinner meetings, mathematics partnership programs, and the publication of a collaborative newsletter. In addition, the ITL Groups also functioned as major communication channels

between the teachers and the collaborative administration, and many teachers served on curriculum committees, increasing the feeling of collaboration among their peers. Another goal of the collaborative was to educate the community about the professional nature of mathematics teachers and about the important role of mathematics. Consequently, in 1989-90, the collaborative made a concerted effort to promote Mathematics Awareness Week.

Receptions

Over the five-year period, the collaborative sponsored seven receptions for Pittsburgh mathematics teachers: one in June, 1986; one in June, 1988; three during the 1988-89 school year; and two during the 1989-90 school year. Three of the receptions were held to celebrate successful school years, and all but one featured a special guest. The June 1986 reception, which was held for Barbara Scott Nelson of the Ford Foundation, provided an opportunity for collaborative members to celebrate the first year of the collaborative. Fifty-nine people attended, including teachers, representatives from business and industry, and university faculty. The June 1988 wine and cheese reception, held for all Pittsburgh secondary and middle school mathematics teachers, featured Bill Zlatos, the education writer for the Pittsburgh Press. Eighty teachers attended the reception. During the 1988-89 school year, secondary and middle school teachers were charged a $5 fee for attending the first two wine and cheese receptions. Both of the receptions, which were held after school, featured formal presentations. At the first reception, attended by 31 teachers, Cheryl Rambler of Gate-way Penn Financial Services presented a seminar on Pre-Retirement and Financial Planning. Terry Balko, a national consultant for mathematics and science for the Houghton Mifflin Company and a former mathematics teacher, demonstrated calculus, logic, geometry, probability and statistics, and topology activities at the second reception, which was attended by 30 teachers. By the third wine-and-cheese reception, which was held at the Buhl Science Center to celebrate a successful 1988-89 school year, the collaborative had decided not to charge a fee. The reception provided an opportunity for teachers to talk with one another and to explore the Center's exhibits. The first reception of the 1989-90 school year was held following a presentation by Michael Serra, author of *Discovering Geometry* and a member of the San Francisco Urban Mathematics Collaborative. The reception took place during the

regularly scheduled Teacher Interaction Period (TIP), which was significant since it was the first time the mathematics department received permission from the district to use TIP time for a district-wide gathering. Because the reception was scheduled during TIP time, all secondary mathematics teachers were required to participate. The final reception of the 1989-90 school year, an end-of-year celebration, featured author and Ohio State University Mathematics Professor Frank Demana, who addressed the issue of how new developments in technology are changing the roles of mathematics teachers, students, and traditional subject matter for Grades 9-12. The reception was the first to be completely planned by the Collaborative Liaison Committee, rather than by the collaborative administration. Approximately 45 teachers attended the reception, which was designed to foster professional development and to promote collegiality.

Kick-Off Events

The collaborative sponsored two "kick-off" events to begin a new school year, one in September, 1987, and one in September, 1989. The 1987 kick-off social was held at the home of the collaborative coordinator. The mathematics department chair from each high school as well as the district director and supervisors for mathematics were invited, along with their spouses. For the kick-off at the beginning of the 1989 school year, a picnic was held. All Pittsburgh middle school and high school mathematics teachers and their families were invited.

Dinner Meetings

The collaborative sponsored two dinner meetings for secondary mathematics teachers during the five-year period. The September 1986 Dinner Meeting, which was attended by 51 teachers, featured a presentation, "Economic Development in the Pittsburgh Region." The February 1988 Dinner Meeting featured Dr. Edward Silver, formerly of San Diego State University and now of the University of Pittsburgh, who spoke on the topic, "Emerging Visions of Mathematics Education." Dr. Silver emphasized the importance of problem solving and stressed that teachers must help their students develop communication and reasoning skills that encompass conjectures, argumentation, and formal proof. While the first dinner meeting was complimentary, the 38 teachers and

supervisors who attended the 1988 dinner meeting each paid $15. One issue being evaluated at the dinner meeting was whether teachers would be willing to pay to attend an enrichment activity.

In addition to the two dinner meetings held for all secondary mathematics teachers, the collaborative also held two dinner meetings to establish collaborative committees--the Collaborative Liaison Committee and the middle school Instructional Teacher Leaders Group. The collaborative administrators felt that the dinners, which were held in October and November, 1988, provided a positive working atmosphere and a good start for the committees. On the day following each of the dinners, which were hosted by local businesses, the collaborative sponsored a half-day workshop for committee members.

Mathematics Intensive Partnership Program

In order to encourage increased rapport between representatives of business and industry and the secondary mathematics teachers in the city schools, the collaborative has encouraged the formation of individually defined math-intensive partnerships. The first such partnership, initiated during the 1987-88 school year, was established between PPG Industries and Langley High School. The project centered on a tutoring program through which PPG employees tutored Algebra and Geometry students on Saturday mornings. During the 1989-90 school year, Langley and PPG Industries initiated a new project, "Future Jobs," that focused on the mathematics needs of non-college bound students.

Collaborative Newsletter

In fall, 1987, the collaborative initiated the publication of *GRAPHiti*, a newsletter for secondary mathematics teachers. The newsletter was issued twice during the 1987-88 school year and once during the 1988-89 school year. The newsletter, edited by the collaborative's assistant coordinator and the district's mathematics supervisor, was a vehicle for publicizing and promoting collaborative events. In addition, the newsletter contained information on personnel changes, honors given to teachers, computer instruction, professional enrichment grants, regional and national workshops,

employability skills, and teachers' activities. The newsletter also featured articles by teachers about their conference experiences.

Mathematics Awareness Week

The Pittsburgh Mathematics Collaborative worked to promote Mathematics Awareness Week in April, 1990. The collaborative organized a Speakers Bureau of professionals in mathematics-related fields who were prepared to speak with students about mathematics applications in the workplace. Through the Bureau, speakers were placed in 35 classrooms during the week. Drs. Salmon-Cox and Briars met with local newspapers to request editorials on the importance of mathematics education; they also prepared public service announcements encouraging students to expand their career options by studying mathematics. The collaborative also organized a "Problem of the Day" mathematics contest for students.

Increased Knowledge of Mathematics Education

A major goal of the collaborative was to enhance teachers' knowledge of mathematics applications. One objective was to identify the mathematics skills needed by students entering the workforce with either a high school diploma or limited vocational training. In the first years of the collaborative, most of its programs were directed at this effort and were sponsored by local industries. Not only was the information gathered important, but the programs were regarded as an effective beginning in establishing cooperative initiatives between industry and schools. Later, the emphasis on collaborative programming changed to address the need for curriculum reform, including increasing the use of technology in the mathematics curriculum, increasing the level of mathematics for all students, and initiating a new approach to teaching geometry. In addition to sponsoring speakers at receptions and dinner meetings, the collaborative planned programs specifically to increase teachers' knowledge of mathematics and the mathematics curriculum. These included seminars, industry tours, computer training, and programming at district inservices.

Seminars

The collaborative sponsored two seminars, one in April, 1986, and one in April, 1987. The first seminar, "Customized Job Training: Meeting Local Industry's Needs for Qualified Workers," focused on the educational skills necessary for non-college-bound students to succeed in the workplace. The second seminar, "Mathematics and Proprietary Schools," was co-sponsored with the Pittsburgh Association of Private School Administrators. The seminar featured a panel of representatives from Pittsburgh area proprietary schools discussing the mathematics background needed by their students, the mathematics offered in their programs, on-the-job uses of mathematics, perceptions that mathematics students bring with them, and effective training techniques.

Industry Tours

The collaborative sponsored two tours of local businesses and industries. Individual teachers participated in planning visits to convey to their industrial hosts what teachers would like to learn during the visits. Teachers received information about the host corporation, future directions and job potential in the corporation, and information about the mathematics required to perform these jobs. Teachers and corporate representatives were encouraged to discuss the mathematics preparation needed for successful entry into the workplace. In May, 1986, the collaborative sponsored a day-long high technology tour of the Regional Industrial Development Corporation (RIDC) Industrial Park. Thirteen teachers and four mathematics supervisors were among the 26 participants. In February, 1987, the collaborative, in conjunction with Duquesne Light Company, sponsored a tour and discussion at the Beaver Valley Power Station. During the full-day program, teachers participated in an informal discussion with Beaver Power personnel of mathematics and science applications, and participants received handouts of sample mathematical problems that had been encountered by employees at the power station.

In addition to these two collaborative-sponsored tours, teachers had the opportunity to participate in five tours that were scheduled as part of the district's Cluster Inservice Program, which the collaborative helped to plan. These tours were of the

Equibank Headquarters, the Westinghouse Nuclear Training Center, Dravo Automation Science Facilities, Blue Cross, and Rockwell International.

Computer Training

In August, 1986, the Pittsburgh Mathematics Collaborative received a $20,000 challenge grant from the Pennsylvania Ben Franklin Partnership Program to provide a select group of secondary mathematics teachers with computer literacy training. Ten teachers were trained to use computers in teaching mathematics over the course of the 1986-87 school year and continued to meet throughout the period of this report. Their activities are discussed under the heading "Teacher Professionalism."

Inservice Days

During the 1986-87 school year, as a direct result of the joint efforts of the collaborative coordinator and the school district's director of mathematics, the district initiated cluster inservice days. Twice a year, the mathematics teachers from several high schools that are geographically proximate met for a half day of inservice education. In addition to the cluster inservice programs, each year the district and the collaborative sponsored one or two half days of inservice that were attended by all PPS high school mathematics teachers. The inservice programs were designed to provide teachers with an opportunity to interact and to hear presentations relating to mathematics. Because attendance at the inservices was mandatory, they provided an efficient and inexpensive way for the collaborative to reach all of the PPS mathematics teachers. Many of the programs were conducted by the district's Division of Mathematics, with the collaborative playing a tangential role. The programs, which addressed topics directly related to the goals of the collaborative, were planned with the input of the secondary ITLs and often featured presentations by teachers who have received collaborative support to attend conferences and meetings.

Programming at the cluster inservices included tours of the Equibank Headquarters, the Westinghouse Nuclear Training Center, the Dravo Automation Science Facilities, and Rockwell International, as well as a presentation by Blue Cross on the

actuarial profession and a panel discussion by participants in the Junior Achievement Program; a presentation by district Director of Mathematics Diane Briars on trends in mathematics education on both a local and national basis and a discussion of the NCTM *Curriculum and Evaluation Standards for School Mathematics*; a report on the mathematics collaborative followed by presentations on semester scheduling, Mathematics Assessment Program (MAP) objectives, the Syllabus Examination Project, the Problem Solving I course, elementary functions, and the Computer Instruction Group. Sessions offered by teachers included a presentation on geometry by three teachers who had attended the Woodrow Wilson Institute on Geometry, a workshop on probability, and one on the use of computers in the teaching of mathematics. Round-table discussions addressed Algebra I, Algebra II, Geometry, or Problem-Solving I; a discussion by Dr. Briars of the MAP Performance Assessments for Algebra I, Algebra 2, and Geometry was followed by a presentation by Mary Lynn Raith of the Division of Mathematics on the areas of mathematics being taught in the middle schools, and three concurrent sessions: Problem Solving I, presented by Dr. Briars; the IBM *Mathematics Explorations Toolkit* presented by Richard Wertheimer of the Division of Mathematics; and Using the Graphics Calculator, presented by two teachers from Oliver High School.

Programming at the district-wide inservices was often organized to incorporate concurrent sessions on a variety of topics, such as a discussion by representatives from Blue Cross on spread sheets and presentations by teachers on opportunities that had been provided by the collaborative. Presentations by teachers included a report by a teacher who participated in a week-long conference at Phillips Exeter Academy that focused on the impact and application of the computer on the curriculum, a presentation on computer use in mathematics classes by the Computer Group, and a discussion led by teachers who had attended a North Carolina School of Science and Mathematics workshop on what they had learned there and about the course they were going to offer the following summer; a presentation by Paul Foerster, a high school mathematics teacher from San Antonio, Texas, "The Impact of Calculators and Computers on Algebra I and Subsequent Mathematics Courses," that focused on the importance of selecting problems to which students can relate, followed by four small-group sessions on the topics of the census-teaching resource, problem solving for everyone, geometry, and a question-and-answer session by Mr. Foerster.

The 1990 January district-wide inservice for all secondary mathematics teachers featured a presentation by Richard Wertheimer on the Second International Mathematics Study (SIMS). Following the general session the teachers divided into small groups to discuss the SIMS report and its implications. At the end of the meeting, the teachers were challenged to develop innovative plans for reversing the conditions identified as being factors that inhibit their students in achieving a higher level of proficiency in mathematics. The cluster inservices held in the second half of the 1989-90 school year were an extension of the January district-wide inservice. At the end of the session, each school was asked to develop a proposal to address solutions to some of the problems.

Teacher Professionalism

Over the five-year period, the Pittsburgh Mathematics Collaborative provided experiences and opportunities that both directly and indirectly resulted in enhancing the teachers' sense of professionalism. Through the Professional Development Grant program, teachers had the opportunity to attend a variety of national conferences and meetings of professional organizations. As a result of their participation in these events, Pittsburgh teachers have expanded their collegial relationships to include collaborative members at other sites. This increased interaction of teachers with the larger UMC network was facilitated through teachers' participation on Bread Board, the UMC electronic bulletin board. By the end of the 1989-90 school year, 30 or more teachers were reported to be enrolled on the system.

The collaborative has had a strong impact on the district's increased recognition of teacher professionalism, as indicated by the greater amount of responsibility the district has given to the Instructional Teacher Leaders Groups as well as to the curriculum committees. Collaborative teachers have been integrally involved in developing curriculum and in setting the direction for mathematics education in Pittsburgh through their participation on such committees as the General Mathematics Redesign Group and the Computer Instruction Group as well as through their involvement in projects such as the Geometry Pilot.

Professional Development Grants

In the fall of 1986, the collaborative announced the availability of Professional Development Grants for high school mathematics teachers, through the Allegheny Conference Education Fund. The grants provide teachers with an opportunity to attend professional meetings, workshops, and seminars; to consult with fellow teachers and colleagues in the private sector; and to investigate areas that can enhance their professional life. Individual grants were for up to $300. Teachers were required to submit grant requests 60 days before the event being funded. Over the five-year period, the collaborative awarded approximately 34 grants to teachers. During the 1988-89 school year, the program was expanded to include middle school mathematics teachers, and in 1989-90, new guidelines were established which restricted teachers to one grant application per school year, although special consideration for awarding a second grant was to be given to teachers invited to speak at professional associations or meetings. During the 1987-88 school year, 11 teachers received grants; in 1988-89, 7 teachers received grants; and between February, 1989, and August, 1990, 12 Professional Development Grants were awarded to mathematics teachers. Among the conferences that teachers attended with funding from Professional Development Grants were: meetings of the Pennsylvania Council of Teachers of Mathematics; the 1986, 1987, 1988, 1989, and 1990 Annual Meetings of the National Council of Teachers of Mathematics; a precalculus curriculum workshop at the North Carolina School of Science and Mathematics; the 1987 Mathematics and Computer Conference at Phillips Exeter Academy in New Hampshire; an Advanced Placement Calculus Workshop; a College Board Advanced Placement Institute; a University of Chicago School Mathematics Project meeting; the National Middle School Convention in Toronto; and the TI-81 Graphing Calculator Workshop at Ohio State University.

Middle School Mathematics Project

Dr. Salmon-Cox and Dr. Briars received a major grant from the National Science Foundation to establish a model program for Pittsburgh middle school mathematics teachers. The $438,000 grant, which was awarded to the Learning Research and Development Center for a three-year period beginning in August, 1988, was matched by a contribution of $386,000 from the school district. The three-year program was designed

to include teacher inservice education, follow-up activities in the teachers' home schools, linkages to business and industry, invited speakers, opportunities for teachers to interact with other mathematics professionals, and leadership development for teacher participants. As part of the project, a week-long inservice program was held for middle school mathematics teachers in August, 1988, and in August, 1989. In October, 1989, the district scheduled the first cluster inservice for middle school teachers, which was based on the successful inservice experience of the secondary mathematics teachers. It is anticipated that the Middle School Mathematics Project will result in the formation of a cohort of teachers more knowledgeable about mathematics, issues of instruction, adolescent learning, and related research--in short, mathematics professionals for the middle schools.

Curriculum Development

The collaborative helped to support teachers' participation in district mathematics curriculum committees. Over the five-year period, a variety of teacher committees met to discuss the mathematics curriculum. During the summer of 1986, for example, collaborative funding enabled six teachers to work with Diane Briars to develop district plans for the use of regular and scientific calculators in general mathematics courses. During the 1986-87 school year, teachers were asked to provide feedback on the plans, and a calculator-per-student policy was adopted. Two long-term curriculum committees were established that provided teachers an opportunity to strongly influence the direction of the district's mathematics program--the General Mathematics Redesign Group and the Computer Instruction Group. While these committees were under the jurisdiction of the school district, they received collaborative support as needed. The teachers who served on the curriculum committees felt a responsibility for becoming experts in their particular area and were eager to take advantage of professional opportunities so that they would be better prepared to make important curriculum decisions.

General Mathematics Redesign Group. In response to a 1986 state law that increased high school mathematics requirements from two years to three, the Pittsburgh School District, with the support of the collaborative, established the General Mathematics Redesign Group--a committee of five teachers and a supervisor--whose mandate was curriculum revision. The committee met frequently throughout the 1986-87, 1987-88, and 1988-89 school years and spent the summers of 1987 and 1989 writing curriculum,

supported in part by the collaborative. While the committee was originally charged with redesigning the curriculum for the first year of general mathematics, the committee's charge was extended to cover all three years of what was considered General Mathematics. After identifying the goals for the general mathematics curriculum in light of the NCTM *Standards*, the committee created a course, "Problem Solving I," that introduced techniques in problem solving. Rather than adopting a single textbook, the committee assembled curricular material, including activities in problem solving and data analysis, from more than 20 sources. The course was pilot tested during the 1988-89 school year. The committee plans to continue to develop a Problem Solving II course.

Computer Instruction Group. As mentioned previously, the Pittsburgh Mathematics Collaborative received a challenge grant from the Pennsylvania Ben Franklin Partnership Program to train a select group of ten secondary mathematics teachers to receive computer training to teach mathematics. The teachers began their training during the 1986-87 school year; they met over the summer and monthly during 1987-88 to share their reactions to the software they had reviewed, to design instructional modules for the training of additional teachers, and to create guidelines for the use of computers in mathematics classrooms. During the summer of 1988, the members wrote more than 80 lessons to share with other teachers and, during 1988-89, the group developed and taught an incremental credit course on using the computer to teach mathematics. Approximately 30 teachers participated in the six-week course, which was held in February and March, 1989. When the grant ended at the conclusion of the 1988-89 school year, there were unexpended funds because teachers had refused payment for their time. These funds were used to purchase modems and software to enable high school mathematics departmental offices to communicate with each other, as well as with the Division of Mathematics office at Boggs, which enabled teachers to access the laser printer. In the course of three years, the committee went from a paid group of commissioned teachers to an empowered group of intrinsically motivated teachers who are committed to maintaining their connection with one another. At the 1988-89 meeting of the collaborative Steering Committee, the facilitator of the Computer Group described how the group of teachers had developed into "a group of experts, knowledgeable critics familiar with computers and available software."

Geometry Pilot. Collaborative teachers took the initiative in implementing innovative approaches to teaching geometry. During the 1988-89 school year, five

teachers conducted a pilot test of a new method of teaching geometry at Langley High School. The pilot program was initiated after the collaborative and the school district sent 20 teachers to a Woodrow Wilson Institute on Geometry in summer 1988, where teachers were exposed to an approach teaching geometry that emphasized discovery learning, hands-on experience, and student construction of knowledge. Three teachers from Langley convinced other mathematics teachers in their school to join them in an effort to reorganize the geometry curriculum. During the 1989-90 school year, the revised curriculum was extended to three other high schools. The teachers reported that students seem to have improved their attitude toward geometry from previous years and were more willing to attack problems.

Teacher Leadership

One of the collaborative's primary strategies was to shape the culture of mathematics education in Pittsburgh by strengthening or creating working committees and enhancing the leadership abilities of individual mathematics teachers. As the collaborative built a strong committee-based organizational foundation, teachers were drawn into the decision-making process. As a result, a number of the mathematics teachers in Pittsburgh have assumed leadership roles within their departments and within their schools, as well as within the district as a whole. The secondary Instructional Teacher Leaders Group, the middle school Instructional Teacher Leaders Group, and the Collaborative Liaison Committee--as well as the Computer Training Group, the Mathematics Redesign Group, and the teachers participating in the Geometry Pilot discussed in the previous section--were vehicles through which teachers could develop and then demonstrate leadership skills. Individual teachers have also assumed initiative and leadership in instigating new school-based projects and curriculum studies. Teachers had the opportunity to participate in the development of their departmental intervention plans, and two ITLs submitted a successful proposal to EDC that focused on providing professional development experiences for their colleagues.

In response to a request for proposals to fund grants of up to $10,000 by the UMC Outreach Project, two department chairs developed a proposal to offer teachers concrete techniques for enhancing interaction skills. The proposal, which received full funding, outlines plans for a weekend retreat/conference for 40 to 60 teachers in November, 1990,

to help them develop interpersonal skills including self-assertion, active listening, and sequencing. During the weekend, small groups of teachers from the same school will also design school-based action plans that will be refined and implemented during TIP periods from November, 1990, through February, 1991. At the spring cluster inservices, teachers will discuss and compare their efforts and revise their plans based on what they learn from others. The management of the overall project will be assumed by the two ITLs who authored the successful proposal.

F. Reflections

The intent of the Pittsburgh Mathematics Collaborative--to develop the self-concept of teachers and their knowledge of mathematics, and to work with the larger community to increase its regard for and appreciation of teachers--remained constant over the five-year reporting period. The collaborative's approach in achieving this goal has been to enhance the district's mathematics program and how others respond to it by helping to make small changes in its operations, its decision-making processes, and in the interaction among its teachers. In this way, the collaborative worked to effect change in the district's mathematics community. Because of the underlying plan to become integrated into the school district's program, it is difficult to identify successes that can be attributed directly to the collaborative. What are noticeable are the changes in the operations of the mathematics program that were made by the director of mathematics and, at least in part, by the collaborative.

During the five years documented, all of the over 100 secondary mathematics teachers became involved with the collaborative in some way, with an estimated 40 to 50 very active. These active teachers have taken the initiative and assumed leadership in instigating new school-based projects and curriculum studies and have served on district committees. Recently, a supervisor published an article in the *Mathematics Teacher* and a letter from a Pittsburgh teacher also appeared in an issue of the journal. Many teachers have increased their participation in professional meetings and their interactions with mathematics teachers across the country. Whereas before the collaborative, teachers felt that they had no input into district decision making, now some feel that they do. Both the greater participation by mathematics teachers and their inclusion in the decision-making

process have been important in raising teachers' self-concept; this is evident in their increased professional activity, the greater interaction among mathematics teachers, and their willingness to confront sensitive issues.

To raise the community's awareness of secondary mathematics issues, the collaborative made presentations to the Steering Committee and to the Allegheny Conference Committee, published newspaper articles, participated in radio programs, sponsored teachers' meetings with community leaders, and encouraged teachers to talk with parents of middle and elementary students. It is difficult to judge whether these activities have resulted in greater public awareness of the importance of mathematics in students' educational development and in adults' professional lives--one of the stated goals of the collaborative. Other than the mechanisms that were already in place, new links have not been formed to promote exchange and interaction among teachers and community leaders in business, industry, and higher education. The exchanges that have taken place have tended to be isolated cases rather than evidence that structural change has been built into the system.

The district-infusion approach of collaboration has effectively energized a group of teachers. The success of this approach is attributable to a great extent to the specific individuals who had leading roles. Led by the collaborative coordinator and the district's director of mathematics, the collaborative's governance has been more autocratic than democratic. Because the collaborative's development was so strongly dependent on individuals and on the context, it is not a model that can easily be applied to other districts. However, because of its approach and unique situation, the Pittsburgh Mathematics Collaborative was able to avoid many of the major problems that other collaboratives faced, including the need to raise funds, to develop mechanisms to attract teachers, and to identify leadership among teachers. The collaborative was a relatively low-budget operation that used mandatory district programs for teachers and tapped the existing structure of the department chairs for leadership.

In looking back, questions remain as to whether the collaborative could have accomplished more than it did. Many of the collaborative's successes were accomplished through teachers' work on committees. Teachers who served on the ITLs, the Computer Committee, or the Liaison Committee became very involved in the work of these committees. Committee members, however, had difficulty transferring their energy,

enthusiasm, and knowledge to a second generation of teachers in order to increase their professional activities and knowledge. In many cases, there was little evidence of a "snow balling" effect in collaborative development--i.e., transferring the energy of one group to other groups of teachers. Excitement generally was confined to the group addressing the task or issue. This was evident, for example, in the difficulty in getting teachers who had not served on the Computer Committee to become knowledgeable enough to feel comfortable about incorporating computer technology into their teaching. The challenge of extending innovation to teachers beyond the seminal working committees was never fully met by the collaborative.

Another resource not adequately tapped was the higher education community in the area. A few academicians made spot appearances at some collaborative events, but other than meeting with the coordinator, very little interaction occurred between mathematics teachers and those from the University of Pittsburgh, Carnegie-Mellon University, or Duquesne University. These reservoirs of experience in mathematics education and application remained essentially unexplored. Significant interactions between teachers and those in business were also very limited. Although during the first two years of the collaborative nearly all of the secondary mathematics teachers visited industries to gain an idea of how mathematics was being used in the work place, opportunities did not occur in which teachers could work with people from business in mutually beneficial ways. Such interactions could have helped the collaborative realize its goal of educating the community about the professional nature of mathematics teachers.

Developing situations in which meaningful interaction between teachers and others takes place is time-consuming. One way of involving teachers in educating the community would have been the formation of the Liaison Committee earlier in the collaborative's development and the presence of members of the business and higher education communities on this committee. The committee could have undertaken the challenge of community education. As it was, this type of communication was undertaken primarily by the coordinator and the director of mathematics, who were the spokespersons for the collaborative. On rare occasions, teachers did make presentations to those from business and higher education who were on the Steering Committee, and once a team leader organized a meeting at her school to discuss the issue of high student absenteeism and its educational implications with members of the local community.

One drawback in the strongly-centralized management structure of the collaborative was that the collaborative's administrators were confronted with time constraints. There was also the perception that teachers were being protected from the larger community because the few opportunities to interact with those from other sectors were always in very controlled situations--at site tours and meetings. However, major changes have taken place in the district's mathematics program as a result of the collaborative and a strong core of 40 or 50 teachers has developed. At the end of the five years, these teachers were playing a much more active role in developing curriculum and making decisions about the mathematics program. As the formal structure of the collaborative is subsumed into the district's mathematics program, perhaps teachers will assume more responsibility for meeting the goal of educating the community about the professionalism of high school mathematics teachers.

Collaboration Outcomes

As has already been noted, the major form of collaboration achieved has been among teachers as well as between teachers and the district's mathematics director and supervisors. As one ITL remarked, ". . . one thing that the collaborative does to help is that teachers have gotten to know other math teachers around the city better." This is significant because before the collaborative was established and prior to Dr. Briars' appointment, very little interaction had occurred among mathematics teachers except within a school, and even then, interactions varied greatly. The cluster inservices, the collaborative gatherings, the working committees, and the ITL Groups enabled mathematics teachers to become better acquainted and more comfortable with each other and to work together. The committees strengthened or initiated through the collaborative are cited by teachers as substantive factors in the increased collaboration among their peers.

An important factor in the evolution of these teacher committees and ITL Groups has been that each has had significant tasks to address. By working on these tasks, the members of the group have become involved, have gained knowledge, and have bonded with other members of the group. The director of mathematics has identified individual growth as one important outcome of the collaborative, ". . . it's not necessarily a particular project, it is how particular individuals have really grown and changed . . . that is going to

stay around." The strategy of using committees to energize teachers appears to be effective when each group has a unique, well-defined task to accomplish. The strategy has been less effective in spreading committee members' enthusiasm to other teachers or forming second committees, such as a second computer committee.

One benefit realized by teachers as a result of collaborative participation has been the interaction with teachers from other cities. The increased interaction of Pittsburgh teachers and staff with the larger UMC network of teachers has been facilitated through Bread Board, the UMC electronic bulletin board. By the end of the 1989-90 school year, 30 or more Pittsburgh teachers were reported to be enrolled on the system. Two teachers and a mathematics supervisor were extremely active contributors with respect to issues of equity, assessment, and geometry.

The collaborative has brought the agenda of mathematics education to the attention of chief executive officers of the major corporations in Pittsburgh. However, according to the chair of the collaborative Steering Committee, getting the business community involved in the collaborative and with teachers has been one of the most difficult parts of collaboration. Although he feels that the support of CEOs is important, the really meaningful commitments will come from those at the middle level when they are given specific assignments. He pointed out, however, that people in education seem reluctant to make such requests. Thus, while the collaborative has made some of the influential people in business aware of what it is doing, it has not been successful in actively involving businesspersons on specific tasks.

Professionalism Outcomes

The greatest impact of the collaborative, as reported by teachers, has been an increase in their professional activities and in their feeling of empowerment. Because of the collaborative, teachers report feeling less isolated. They now feel that they are members of a professional group with common goals and interests, are better informed and more willing to participate in professional activities, and are experiencing increased sharing among their peers. Thus, the climate for mathematics education in the district has changed, making mathematics teachers more willing to deviate from the status quo. Since the collaborative was initiated at the same time the current director of mathematics was

appointed, it is difficult to distinguish the singular impact of one over the other. As the collaborative has merged with the district, teachers and others cite it as a factor in creating the positive environment in mathematics education that now exists in Pittsburgh.

An associate superintendent has observed a difference in the attitude of secondary mathematics teachers. In the early 1980s, the district had tried to work with teachers to reduce the more than 30 different mathematics courses being offered and to offer algebra to all students before graduating. But teachers resisted this change and little progress was made. Since the collaborative became established, the number of mathematics courses has been reduced to 15 and the three tracks--academic, skill, and general--reduced to two, academic and skill (vocational). This superintendent credits the collaborative with contributing to the creation of an environment in which mathematics teachers are much more receptive to change.

Teachers have valued the funding they received through the collaborative in the form of Professional Education Grants. These grants have given them the opportunity to attend professional meetings, some for the first time. Opening these doors has enabled teachers to make presentations at professional meetings and has encouraged them to submit articles to professional journals.

The secondary ITL Group, energized as a result of collaborative activities, is involved in important decision making and has had greater input into district assessment practices than it did prior to the existence of the collaborative. The individual department heads are more willing to convey information back to their departments and to get input from their colleagues. The ITLs played an important role in developing a strategy for increasing the collaborative's impact on classroom practices. As a follow-up to one inservice, ITLs were asked to work with their departments to develop intervention plans, thereby involving other teachers in the decision-making process. The collaborative has also assisted the ITLs in effecting change by helping them to acquire greater skill at working with other teachers. Before the collaborative, the main training that ITLs received through the district involved observing teachers and giving them feedback on their teaching. To become an ITL required nomination by the department and then appointment by the principal, a process which required that the ITL fit in with the other teachers and be acceptable to the principal, both factors that pressured ITLs to be conformists rather than leaders. Because of the collaborative, the ITL Groups increasingly

serve as a source of support and of information, enabling their members to become leaders within their departments rather than primarily observers.

In response to the 1990 Survey of Teacher Professionalism, teachers who participated to a greater degree in the collaborative portrayed themselves as reasonably dedicated to an occupation they believed had great social benefit. This commitment to their work is set against their belief that the community as a whole does not sufficiently value the teaching of mathematics. Almost all respondents reported a very strong self-image as teachers rather than as mathematicians. Nevertheless, most saw the value in and were comfortable with interacting with mathematicians and other users of mathematics.

Collaborative teachers valued continued mathematics training. However, the degree to which training in mathematics was seen to be more important than working to enhance teaching and classroom management skills varied considerably among teachers. They also varied greatly in their belief that mathematics teachers should have prime responsibility for the evaluation of their peers and their work. Teachers did generally agree that they had sufficient control over day-to-day decisions.

The extent to which the respondents to the survey believed that professional organizations should have responsibility for setting standards and implementing reforms corresponded directly to a teacher's level of participation in the collaborative. Of those teachers who were Occasional participants in collaborative activities, about 20 percent disagreed that professional organizations should have this role. Of those teachers who were Frequent participants, only 10 percent disagreed. Thus, active collaborative teachers tended to be in favor of professional organizations assuming more responsibility for setting standards and for initiating reform. However, even given this finding, a large proportion of teachers did not participate in professional organizations. Slightly less than half of the responding teachers indicated that they regularly attended activities of professional organizations or felt that such organizations made contributions to the worklife of an average mathematics teacher.

Teachers have responded to the challenge of heightened professionalism differently. While some became more involved in professional organizations, others channeled their increased professionalism in other ways. One teacher became more assertive in addressing problems of student absenteeism and achievement and attributed

this change to the training she received through the collaborative. To help solve the absenteeism problem, she initiated a study of the relationship among failing grades, attendance, and ethnicity, and then organized a meeting of community leaders, parents, and business people to address the issue. From the 161 invitations sent, nearly 20 people came to the meeting. She credited being active in the collaborative with motivating her to take such initiative, something she had never done before.

Mathematics teachers active in the collaborative reported that it has enhanced their professionalism. One teacher described the collaborative as a professional organization that has helped her think of herself as a professional. Previously, she viewed herself as a teacher--a term without such a positive connotation. The difference occurred for her with the relationships she formed with other mathematics teachers through the collaborative. Others feel that the collaborative has kept them informed of the current trends in mathematics education and that this increased knowledge contributed to their sense of professionalism. Teachers who have not been reached by the collaborative are described by other teachers as "not being very professional."

Mathematics Focus Outcomes

The mathematics focus of the Pittsburgh Mathematics Collaborative has been strongly influenced by Dr. Briars. She has had the support of the district administration and has gained the support of the ITLs. During the collaborative's existence, which corresponded to Dr. Briars' tenure, several changes in the mathematics program were implemented, stimulated by current national reform initiatives. As one active collaborative teacher observed, "Everything we do is based on the changes [advocated] in the *Standards*".

The total number of mathematics courses offered by the district has been reduced by half; there are now approximately 15 courses. A problem-solving course was developed by a committee of teachers to replace the former general mathematics course given to 9th-graders who were considered unprepared for algebra. Rather than being driven by traditional concepts and computation, the new course presents students with a range of mathematical experiences including statistics, problem solving, graphing, and equations.

Following the first problem-solving course, most students are expected to take Algebra I, although a Problem Solving II course will be developed for those who do not.

The collaborative has also increased the use of technology by secondary mathematics teachers. The Computer Committee, composed of one member from each high school, has reviewed a range of software applicable to the teaching of mathematics and is available to help other teachers become more comfortable using computers in class. As a result, there is a wider use of computers, primarily by those on the Computer Committee but to a certain extent by other teachers as well. The collaborative helped to finance an initiative that enabled every high school mathematics teacher to have classroom calculators, computers, and inservices have been offered to demonstrate the use of calculators. A course has been developed around the use of the graphing calculator. Whereas one of the first tasks given the ITLs was to develop a policy statement on the classroom use of calculators, computers, and other forms of technology are now integral to the mathematics program in Pittsburgh. The collaborative facilitated this change.

Finally, teachers are using one another more as resources. They are sharing materials they have developed and are working with one another in piloting textbooks to assist them in deciding what books to adopt. As a result of these actions, the mathematics program in Pittsburgh is beginning to reflect the most current trends in mathematics education toward increased use of technology, problem solving, and reasoning in the mathematics classroom.

Conclusions

The Pittsburgh Mathematics Collaborative's model of introducing cultural changes within the district's structure has worked well, largely due to the working styles of those in the collaborative administration, the receptiveness of the district to changing its mathematics program, and the interest of supervisors and teachers in making program changes. This model would be very difficult to export to other districts. The Pittsburgh Mathematics Collaborative has demonstrated the potential to make structural changes within a district that can continue beyond the active life of the collaborative. This has been accomplished, not by spending large sums of money, but by targeting the changes to the existing structure of the district's mathematics program, such as forming the

Instructional Team Leaders Groups. There have been some trade-offs to having a highly centralized organization. There are a number of silent teachers who have not served on district committees and who have not been reached; they continue their teaching much as they have in the past. It is clear, however, that many teachers have changed through the combined efforts of the collaborative and the director of mathematics. Teacher-based decision making is beginning to occur within the district's mathematics program. This and the curriculum changes that have already taken place are evidence that the collaborative has contributed to the creation of a dynamic mathematics program that has permeated the system. Mathematics teachers are less passive than they were before the advent of the collaborative and are beginning to challenge some of the basic assumptions of the courses they teach as well as of the operations of the schools where they work. In these ways, a new culture is being molded within the mathematics program of the Pittsburgh Public Schools.

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